XVI. *On the Natural History, Anatomy and Development of the Oil Beetle,* Meloë, *more especially of* Meloë cicatricosus, *Leach.* *By* George Newport, *F.R.S., F.L.S., Fellow of the Royal College of Surgeons, &c.*

First Memoir.

The Natural History of Meloë.

Read November 18th, 1845.

THE habits and economy of the genus *Meloë* of Linnæus have constituted one of the most curious and difficult problems in the natural history of the *Articulata* that have remained unsolved to the present day. Although many most zealous naturalists have devoted much attention to these insects, which are of large size, and are found in abundance in our meadows throughout the spring and summer, no one has hitherto succeeded in tracing out the whole of their metamorphoses, or in gaining any satisfactory information respecting their general economy. Some of the older naturalists, Mouffet, Gœdart, Frisch, Geoffroy, DeGeer and Linnæus, and all modern observers, have described the perfect insects very accurately; and some of the former, Gœdart, Frisch and DeGeer, have even given detailed observations on the oviposition of the female, on the eggs, and on the early stage of the larva; but beyond this they have been unable to pursue their inquirics. No account whatever has been given of the adult larva, of the nymph, or of the first appearance of the perfect insect.

This blank in the natural history of an entire genus of our most common insects has arisen in part from the anomalous habits of the species, which seem to exist in the early periods of their life as parasites, and in the later as purely vegetable feeders. It has also in part arisen from the doubts that have repeatedly been expressed of the accuracy of the statements made by the three distinguished naturalists just mentioned respecting the earliest stage of the larva, and of the probability of the conclusions to which they seemed

to lead, respecting so extraordinary a change in the economy of an insect as that of its passing from a life of parasitism to one of a totally opposite condition. But such indeed appears to be the fact; and the details of the observations I am about to communicate ought perhaps to teach us not to treat with contumely or doubt that which we are unable positively to disprove, however strange or anomalous any statements of direct observations may appear, or however incongruous they may seem to be with established facts, when such statements are made by observers of otherwise acknowledged credit.

It is now more than fifteen years ago since I first endeavoured to trace the changes of *Meloë*; but although I succeeded at that time, and through several following years, in observing the deposition of the eggs, and in obtaining the larvæ from them, and also in procuring the adult larva, the nymph, and the perfect insect before it left the cell in which it had undergone its metamorphoses, I have been unable to obtain the means, so satisfactorily as I could have wished, of showing the transitional forms which the larva assumes in passing from its earliest to its full-grown state. On this account I have forborne to make known the facts I have been for many years acquainted with respecting these insects. Fearing however that I may not again have an opportunity of pursuing this inquiry, I now propose to communicate these facts to the Linnean Society, in the hope that some naturalist, more fortunate than myself, may complete the investigation.

1. Of the Perfect Insect.

The species of *Meloë* that have been the subjects of my inquiry, are *Meloë proscarabæus*, *M. violaceus*, and *M. cicatricosus*, but more especially the latter, although the whole very closely resemble each other in form as well as in their habits and economy.

My observations have been made at intervals since the year 1830, on specimens obtained from a vertical bank of clay and sand that forms the south-eastern boundary of the ruins of the Roman castle at Richborough, near Sandwich in Kent, where these insects, at their proper season, are most abundant. The perfect insects come forth at that place very early in the spring, and sometimes, when the temperature of the atmosphere has become suddenly elevated for a few days, even long before the plants on which they

feed are in flower. *Meloë proscarabæus* and *M. violaceus* usually make their first appearance at the end of March, but I have occasionally found the latter as early as the 8th of that month. They are in greatest abundance during the last ten days of March and the beginning of April. *M. cicatricosus* is from ten days to a fortnight later than the other species. In other localities I have not met with these insects quite so early, and there is reason to believe that the time of their coming forth is much influenced by the temperature of the atmosphere, and of the locality in which they undergo their transformations. Goedart* speaks of *M. proscarabæus* as occurring in the beginning of May; and this also is the period stated by DeGeer†, so that in the northern parts of Europe they come forth later than in this country.

When the Meloës first leave their cells they are feeble, move slowly, and have their bodies very small, shrivelled, and contracted. But when they have been feeding for a few days their bodies are greatly enlarged, and the abdomen of the female is expanded to more than twice its original length and diameter, owing to the immense quantity of ova within it in course of development. In *Meloë cicatricosus* it often measures nearly an inch and a half in length, and seems to be dragged along with much difficulty.

The favourite food of *Meloë* is the wild ranunculus, or buttercup, *Ranunculus acris*, more especially the blossoms, which it devours with avidity. *M. cicatricosus* feeds also on the leaves and flowers of the dandelion, *Taraxacum*. Goedart says they feed on the wood anemone. DeGeer found them eat the leaves of dandelion with eagerness, but they would not touch strawberry-leaves, grass, cow-cress, alchemilla, or wild chervil. When deprived for a few days of their proper food, and urged by hunger, they will sometimes nibble blades of grass, but they cannot subsist on it, and soon perish.

The Meloës are extremely fond of basking in the hot sunshine, and it is during the early and middle part of the day that they come most abroad and are most active. When confined in boxes, for the purpose of observing their habits, it is necessary to expose them much to the sun, and to supply them with an abundance of food. They then become as active as when abroad in the fields, and their proceedings are easily watched. They drink freely of water,

* Métamorphoses Naturelles, ou Histoire des Insectes. À la Haye, 1700, 12mo, tom. ii. p. 180.

† Mémoires pour l'Histoire des Insectes, tom. v. Mém. i. p. 3 *et seq.*

and not only require their food to be fresh-gathered, but also that it should be frequently wetted, otherwise they will not thrive. They pair during the forenoon and middle part of a very fine day, a few days after they have left their hybernacula. The males are exceedingly salacious, and traverse the fields with great rapidity in search of their partners. When the object of solicitude is discovered, the male salutes her on the thorax and body with his antennæ, and vibrating his palpi rapidly with delight, repeatedly touches her lightly on the upper part of the head and front with these organs, as if caressing her with great earnestness. The connubial intercourse often lasts from two to three hours, during which the antennæ of the female are clasped by those of her partner, and she continues to feed as if almost unconscious of his presence.

When the two sexes of different species of *Meloë* are confined together, an intercourse sometimes takes place between them; the male of *M. violaceus* with the female of *M. proscarabæus*, and *vice versâ*; and sometimes the male of one of these species with the female of *M. cicatricosus*. But I have never observed this aberration of instinct when the insects are at large in their native haunts, although it is well-known to occur between different species of another family, the *Telephoridæ*. The males are exceedingly pugnacious, and often fight and deprive each other of one of the antennæ.

The eggs are deposited a few days after impregnation; but when this has been retarded, oviposition may take place within a very few hours. An impregnated female, captured by Goedart on the 5th of May, did not deposit her eggs until the 12th, a period of seven days. But even this period may be greatly extended, as it is in part subject to the will of the insect. If there is no place in which the parent can deposit her eggs in safety, she will sometimes die without depositing them at all. Goedart* and DeGeer† have stated that the *Meloë* deposits her eggs in the earth, and the accuracy of this statement I have repeatedly confirmed. In the afternoon of the 6th of April 1830, I first observed a female *M. violaceus* busily employed in digging a hole beneath a turf of grass at the side of a dry footpath. At the time I discovered her she had penetrated to the depth of an inch in an inclined direction. In less than half an hour she had finished her excavation, and having

* Goed. Métamor., tome ii. † DeGeer, Mém., tome v. pp. 8–12.

turned round, projected her body into it, and remained with her head just perceptible at the entrance. In this state she continued undisturbed for several hours; and when I again visited the spot I found the entrance closed up with earth, and the *Meloë* gone. On examining the hole I discovered within it a small packet of eggs. I then placed some earth and a turf of grass in my breeding-cage, in which I had confined several impregnated females. On the following day I observed a female *M. violaceus* in the act of digging a hole beneath the turf sufficiently large to admit of her turning round. The depth of the hole when finished was about two inches. When she had completed her labour, she projected her body into the hole as far as possible, and remained within it, with her head only exposed, for about two hours. During this time, as in the previous observation, the *Meloë* was in the act of oviposition. When she had completely disburthened herself she came forth, and raked the earth with her feet into the hole, until she had entirely closed the entrance. While thus employed she scratched with her claws, and moved backwards like a rabbit in its burrow, and frequently pulled down with the earth small fibres of the roots of grass, which I then supposed were intended to serve as food for the future larvæ, a supposition which was afterwards proved to be erroneous.

When the *Meloë* had completed her labour, I removed the turf, and found the eggs deposited beneath it in a large closely-packed heap. I then placed them in a tin box and covered them lightly with earth to watch their development. This was on the afternoon of the 8th of April 1830. Since that period I have had many opportunities of observing different species of *Meloë* deposit their eggs, which they always conceal in little burrows, excavated for the purpose among the roots of a turf of grass, in a dry soil, and seldom at a greater depth than two inches. Those specimens which I have seen at liberty in their native haunts have usually made their burrows near a dry footpath, or in some situation exposed to the sun.

Thus, by confining the sexes in a large box, partly filled with earth and a turf of grass, placed in the sun and well-supplied with food and water, I have been enabled to obtain an abundance of ova from every species for investigation, and from all of them little hexapod larvæ have invariably been developed in from three to five or six weeks, according to circumstances, which I shall presently explain.

When an unimpregnated female *Meloë* is confined without her partner, and is well-supplied with food, the ova are developed within her, and her body becomes more than usually enlarged, owing to the maturation of other ova besides those which are ready for fecundation. If this is still withheld, she will not deposit her eggs, but soon evinces symptoms of great anxiety, and ceases to feed. If the pairing of the sexes is not then consummated, she traverses her prison in a state of great excitement, examining every side of it, and trying to effect her escape. After a few days she becomes more quiet, and excavates her burrow, and like some Lepidoptera, deposits her eggs unimpregnated; but her instinct is then affected, and she leaves the burrow open, without covering the eggs with earth, after which she very soon dies.

When a female has been fecundated at the proper period, she always deposits two, and sometimes even three or four separate layings of eggs, at intervals of from one to two or three weeks. The first laying of eggs is always the most abundant. The number of eggs then deposited is at least three or four thousand. In order to ascertain the exact number produced by *M. proscarabæus* at her first laying, I removed the ovaries from a specimen that had been impregnated, and having divided one of these into several portions beneath the microscope, I counted the number of eggs in each portion separately, and found that the total number in one ovary amounted to two thousand one hundred and nine perfectly-formed eggs, all ready for exclusion; so that the two ovaries contained the astonishing number of four thousand two hundred and eighteen eggs. Perhaps it may be well here to state, that the eggs of *Meloë* are developed each in a separate ovisac, on the exterior of two uterus-like ovaries, or enlarged oviducts, into which they descend before they are impregnated. Nearly the whole of these are deposited at the first laying, their impregnation being effected from the orifice of the spermatheca, as they pass along the common oviduct near its outlet. When the matured egg has descended from its ovisac into the ovary, the mouth of the ovisac is again closed, and a new egg-germ immediately passes into the sac from the ovarial capsule attached to it; and this germ, when fully developed, constitutes the egg of the second laying. When this egg has passed into the ovary, another germ takes its place, and is the egg of the third laying, and so on with each

development of ova. This explains the fact of the extreme enlargement of the body of the unimpregnated female, in which the first set of eggs have passed into the ovaries and are ready for fecundation while a second set are in the course of development in the ovisacs.

The number of eggs deposited at the second laying is always smaller than at the first, and at the third and subsequent ones smaller than at the second; since the great object of nature, the continuation of the species, being fulfilled in the first instance, the vital and functional powers of the animal begin immediately to decline. This occurs with both the sexes. The males soon disappear, and the females alone survive for a few weeks after pairing, which I believe takes place only once with each female. Those Meloës which are seen abroad after the end of April are almost always females, scattered solitarily over the fields, wandering in quest of food, or of a proper locality for the deposition of their eggs, after which they also perish.

The fecundity of *Meloë* is sometimes greater than that which I have already stated. On the 1st of May 1836 I captured a *M. proscarabæus* in the act of digging her burrow beneath grass at the side of a footpath. I placed her alone in a glass vessel filled with mould and a turf, and she soon began to excavate beneath it. Early on the morning of the 5th of May she deposited a moderate-sized packet of eggs, and at eleven o'clock came forth again to feed, with her body reduced to less than half its previous dimensions. She ate voraciously; and in less than four days her abdomen had again attained its former size, and she appeared as though she had not deposited any ova. On the 12th of May she deposited the second laying, and a few days afterwards a third, and on the 25th of May a fourth packet. On each occasion she formed her burrow beneath the grass, and always before leaving it covered her eggs completely with earth. This fact of four packets of eggs being deposited by the same individual within the short space of twenty-one days is exceedingly interesting, and most distinctly proves that one impregnation only is necessary to fecundate all the eggs a female may produce during her entire life, as in this instance there was no intercourse between the sexes. It is interesting also with reference to the rapid development of the germ. After each deposition of eggs the body of the insect was reduced to a small size, and she took food with great eagerness; but within a very few days it was enlarged again

by the development of fresh ova, and was again reduced on the deposition of these preparatory to the maturation of others.

These observations coincide with those formerly made by Goedart*, who found that a specimen of *M. proscarabæus* confined in a vessel alone deposited a second packet of eggs at the end of twenty-one days, but the number produced on the second occasion was not so great as on the first. Goedart says that he counted in his first packet two thousand and six, but that he had reason to believe there were more than three thousand. On the second occasion he counted nine hundred and six larvæ, but he remarks that there were a vast many more which he was unable to reckon.

2. Of the Egg and Larva.

The eggs of all the species are similar in form and colour, and only differ a little in size. When first deposited they are about one-twentieth of an inch in length, very slightly conical, but obtuse at both ends, and of a bright orange. The shell is transparent, coriaceous, flexible, and exceedingly delicate. Although it is not my intention at the present moment to enter on a lengthened account of the internal structure of the ovum, and the evolution of the embryo, which I shall leave for a future part of this paper, I may here state that the contents of the egg are an orange-coloured yelk, composed as usual of distinct cells, and surrounded by a very small quantity of transparent, colourless albumen-like fluid. Near the middle of the unimpregnated egg, on the surface of the yelk, and projecting slightly from it, a small rounded body, the germinal vesicle, is distinctly visible. When the egg is impregnated, and is deposited in the earth, this vesicle has disappeared, preparatory to the commencement of organization. I am not certain whether the manner in which the eggs are arranged in the burrow may have any special reference to the development of the young, but it is worthy of remark, that they always lie parallel to each other, and adhere together at their sides, with one end directed to the entrance of the burrow.

The length of time that intervenes between the deposition of the egg and the appearance of the larva is subject to much variation. It seems to differ a little in different species, but in each depends much on the temperature of the

* Mém., tome ii. p. 180.

season. Goedart found the eggs of *M. proscarabæus*, deposited on the 12th of May, produce larvæ on the 23rd of June, a period of forty-three days; while DeGeer shows that eggs deposited by this species on the 18th of May produced young on the 19th of June, a period of only thirty-three days. In the packets of eggs watched by myself, I have found a much greater difference in the time of evolution. The first packet of eggs, obtained on the 8th of April 1830, and inclosed in a tin box on the window-sill of my chamber, were developed early on the morning of the 25th of May, a period of forty-seven days; while another packet, deposited by the same species, *M. violaceus*, on the 26th of April 1842, produced young on the 2nd of June, a period of thirty-three days. From other eggs deposited by *M. proscarabæus* on the 29th of April, the larvæ came forth on the 3rd of June, a period of only thirty-six days. In another instance, from a packet of eggs deposited on the evening of the 1st of May, some of the larvæ came forth on the 3rd of June, or at thirty-four days; while the greater number of them did not come forth until the 5th, and a few remained until the 6th. Those of another brood, deposited on the 30th of April, and placed under precisely the same circumstances in regard to locality and temperature as the last, also made their appearance on the 6th of June. On the other hand, larvæ were produced on the 14th of June from a packet of eggs that were deposited on the 24th of May, an interval of only twenty-one days. During this latter period the temperature of the atmosphere was very much higher than in the earlier part of May and April, and ranged from 70° Fahr. upwards. On the 13th of June, the day before the larvæ came forth, it was as high as 81° Fahr.

From these facts we may conclude that the average period of the egg is from four to five weeks; but that the evolution of the embryo is accelerated or retarded by the higher or lower temperature of the season.

When the embryo is fully developed, the egg-shell is burst at its largest extremity, and a little hexapod larva, an active, diminutive creature, that has long been the subject of discussion, gradually withdrawing from its fœtal envelopes, presents itself to view as the progeny of *Meloë*.

So exceedingly dissimilar in every respect is this microscopic and agile little being to its heavy-bodied, slow-moving parent, that we can hardly be surprised that those who have not actually witnessed its evolution from the

egg of *Meloë*, should have somewhat doubted the accounts that have been given of it as the young of that insect. As I have many times witnessed the actual bursting of the egg-shell, and the coming forth of this little hexapod, perhaps it may be well, while adding my testimony to the fact, as already announced by other naturalists, to state the manner in which this is effected.

When the embryo larva is ready for its change, the egg-shell becomes thinned and concave on that side which covers the ventral surface of the body, but is much enlarged, and more convex on the dorsal, especially towards the head. The shell is then burst longitudinally along the middle of the thoracic segments, and the fissure is extended forwards to the head, which then, together with the thoracic segments, is partially forced through the opening, but is not at once entirely withdrawn. The antennæ, parts of the mouth, and legs, are still inclosed within separate envelopes, and retain the larva in this covering in the shell. Efforts are then made to detach the posterior segments of the body, which are gradually released, and with them the antennæ, palpi and legs, and the larva removes itself entirely from the shell and membranes. In this process of evolution the young *Meloë* throws off two distinct coverings:—first, the shell with its lining membrane, the analogue of the membrane in which, as I have elsewhere shown*, the young Myriapod is inclosed, and retained for several days, after the bursting of the ovum, and which represents in the Articulata, not the allantois, but apparently the amnion, of Vertebrata: next, the first, or fœtal deciduation of the tegument; analogous probably to the first change of skin in the Myriapod, after it has escaped from the amnion, and also to the first change which the young Arachnidan invariably undergoes a few days after it has left the egg, and before it can take food. This tegument, which, perhaps, may be analogous to the *vernix caseosa* of Vertebrata, thrown off at the instant of birth, is left by the young *Meloë* with the amnion in the shell; and its separation from the body at this early period seems necessary to fit the insect for the active life it has commenced.

The shell and membranes are so delicate, when the larva has removed from them, that their existence can hardly be detected by the naked eye, and even with a lens of low power they may readily be overlooked, and the ovum seem

* Phil. Trans., part 2, 1841, p. 111.

as if it were transformed directly into a larva, as was supposed by Zier* in regard to the eggs of the blister-fly, *Cantharis vesicatoria*.

The time occupied by the larva in escaping from the egg depends much on the degree of light to which it is exposed. If placed in a strong light it is much hastened; but if in perfect darkness it is greatly retarded. Soon after the larva is rid of its coverings it becomes very active. It is then of a bright yellow colour. It has a slender elongated body, composed of fourteen distinct segments, including the head and anal segment. Four of these constitute the head and trunk, and ten the abdomen. The head is short, broad and depressed, with its front rounded, and marked on its upper surface with a triangular suture, which terminates on each side at the insertion of the antennæ, anterior to the eyes. The antennæ are composed each of five joints; the first and second of which are broad and dilated, and the third, fourth and fifth very small and setaceous. The eyes are large, black, and rounded, and project from the sides of the head. The mouth is formed by a pair of very slender, pointed, and slightly-curved mandibles; a pair of short, thick maxillæ, each bearing an elongated three-jointed palpus, with the terminal joint slightly enlarged; and a narrow, elongated labium, slightly divided in the middle line, and bearing at each side a three-jointed palpus, shorter than that of the maxilla. The three segments that constitute the trunk or thorax are strong and powerful, for the attachment of the legs. The prothorax is wide, with its anterior margin nearly straight, and with its posterior angles rounded. The meso- and meta-thorax also are very large and nearly quadrate. The abdomen, composed of ten segments, is elongated, narrow, and slightly fusiform, with a short stiff hair at the lateral margin of each segment, and with the præanal segment terminated on each side with two elongated setæ. The anal segment, on its under surface, is developed into a pair of short prolegs, which are occasionally employed in walking or climbing, as in some other insects. The true legs of the insect are somewhat elongated. They are formed of a short strong coxa, which gives attachment to a broad femur, that articulates with a long, slender tibia. The tarsus is formed of three distinct, sharp-pointed claws, slightly curved at their apex, and especially adapted for clinging securely to any object.

* Bull. Sc. Nat., Jan. 1830.

This larva is extremely active in all its movements. It runs with great celerity, and then uses only its six true legs. But it can also climb up a nearly smooth and vertical surface, as for instance on glass, or can walk in a reversed position. In these movements it makes use of its anal prolegs. When walking in a reversed position it invariably uses these parts, which are employed in exactly the same way as by the *Iulidæ* and the larvæ of other insects. The body is moved along in the manner of the Geometridous caterpillars; the segments of the abdomen are first shortened and moved forward as far as possible, the prolegs are then attached, and the whole body is projected onwards by a measured step, or as it were a leap.

Such is the larva of *Meloë* immediately after it has left the egg. It then measures about one-twelfth of an inch in length. Thus my own observations, in so far as they relate to the evolution of this larva from the egg of *Meloë*, entirely agree with those originally made by Goedart*, and by DeGeer†, both of whom obtained this little hexapod from eggs deposited by *Meloë*, and both have given very precise details of the fact. Similar observations have since been made by Mr. E. Doubleday‡, Saint Fargeau and Serville§, Brandt and Erichson‖, and still more recently by the Rev. L. Jenyns¶; and yet in face of the direct statements of all these authorities, an acute entomologist of the present day, Mr. Westwood**, conceives himself "warranted" in coming to the conclusion, that this hexapod "cannot be the larva of *Meloë*." In support of this conclusion Mr. Westwood quotes some remarks on *Meloë* by Geoffroy††. But Geoffroy's remarks, respecting the larva of *Meloë*, are incorrect. They appear to have been made on the larva of *Timarcha tenebricosa*, which he seems to have mistaken for that of *Meloë*. Geoffroy says of the full-grown larva of *Meloë*, that it "ressemble beaucoup à l'animal parfait. Elle est de même couleur, grosse, lourde, n'ayant que la tête écailleuse et tout le reste du corps mol. On la trouve enfoncée dans la terre, où elle fait sa métamorphose." This is totally incorrect, in so far as it refers to *Meloë*, but is most accurate as regards the larva of *Timarcha*. Yet not only is this insisted on by Mr. Westwood, in

* Mém. tome ii. p. 181. † Mémoires, tome v. p. 8. ‡ Entom. Mag. vol. ii. p. 453.
§ Encyclop. vol. x. ‖ Nova Acta Acad. Nat. Curios. vol. xvi.
¶ Westwood's Introd. Mod. Classification of Insects, vol. i. p. 302. ** *Loc. cit.*
†† Hist. Nat. Ins. tome i. p. 377.

opposition to the views of three of the most distinguished naturalists, Latreille, Erichson and Brandt, but, entirely misunderstanding a communication made to him by myself respecting the full-grown larva, Mr. Westwood has stated that I have confirmed to him the observation of Geoffroy,—a statement that is quite erroneous. The full-grown larva, as I shall show, is utterly dissimilar to the perfect insect; it has not the scaly head, and it never acquires a black or dark colour, but is always, like the young larva, of a yellow or light orange. The dissimilarity of appearance of the adult larva and imago is as great as that of the full-grown larva and the very young.

It must be acknowledged however, that the very young insect is in every respect calculated to mislead those who have not watched its development from the egg. The structure of its organs of manducation, its prehensile tarsi, and its great activity of body, all seem to point it out as especially fitted, at this stage of its existence, for some peculiar mode of life, very different from that of its parent,—namely, a life of precarious parasitism.

3. Habits of the Larva.

The extreme interest attached to this inquiry has led me to endeavour to ascertain something respecting the habits of this insect. The eggs obtained in my earliest observations in April 1830 were hatched, as I have already stated, on the 25th of May. I saw most of the larvæ leave the egg as early as five o'clock in the morning. They were confined in the tin box for several days, during which time, the light being entirely excluded from them, they remained quiet, and seemed but little disposed to escape. But after remaining in confinement for ten or eleven days, during which the weather had become much warmer, many of them crept out from beneath the lid of the box and moved about with rapidity, agitating their palpi as they ran, as if in search of food. Within a day or two longer nearly the whole of them had removed from the interior of the box, and were distributed thickly over its exterior, and also on the sill of the window, on the side most exposed to the light. I then secured from three to four hundred of them in a phial, into which I put several living *Curculiones*, and a single specimen of *Malachius bipustulatus*. The Curculios remained in the phial undisturbed, but the young Meloës instantly attached themselves in such numbers to the *Malachius* as

almost completely to cover it and deprive it of the power of moving, and most of them remained attached to it for many hours. It was thus evident that their habits are parasitical; but I was unable at that time to ascertain anything further respecting them, as most of them died at the end of a fortnight or three weeks. On the 13th of June, in the same year (1830), I captured a specimen of *Volucella mystacea*, on which I found a parasite that agreed in every respect of form, size, colour and activity with the hexapods I had then lately reared from the eggs of *Meloë*. On the 10th of July, in the preceding year (1829), I had taken a specimen of *Osmia spinulosa*, on which also I found a parasite precisely similar in form, size and activity to the larvæ from the eggs of *Meloë*, and also to that found on *Volucella*, and like which, it attached itself more especially to the posterior part of the thorax of its victim. It inserted its head deeply between the thorax and abdomen, and when removed with the point of a pin, returned with avidity to the same spot. But the specimen found on *Osmia spinulosa* differed entirely from the others in colour. It was deep black, with brown eyes. In this respect it closely agreed with the parasite found by the Rev. Mr. Kirby on *Andrena fuscata**, and regarded by him as distinct from the yellow larva described by Linnæus† and Fabricius as *Pediculus Apis*, and also by M. Leon Dufour‡, as lately as 1828, as a distinct genus of apterous insects, by the name of *Triungulinus Andrenetarum*. I have no doubt of the correctness of Mr. Kirby's opinion, that the larva found by him on *Andrena* was distinct from the yellow larva of *Meloë*, the *Pediculus Apis* of Fabricius; and I have little doubt also of its identity with that taken by myself on *Osmia spinulosa*§. These certainly are not the larvæ of either

* Monog. Ap. Ang. vol. ii. p. 168.

† Systema Naturæ, vol. ii. edit. 12, Holmiæ, 1767, no. 40. p. 1020. Linnæus refers to Frisch's (Ins. fasc. 8. tab. 16) species, the colour of which is the same as that of the larvæ bred from the eggs of *Meloë*.

‡ Annales des Sc. Nat. 1828.

§ Mr. Frederick Smith, who has paid much attention to the Hymenoptera, and has given several valuable papers on the British Bees (Zoologist, 1843, 1844 and 1845), informs me that he has frequently met with these hexapods on the *Andrenidæ* and on the *Nomadæ*, as well as on the dipterous genus *Volucella*. All the specimens he has found on the *Andrenidæ* have been black, like Mr. Kirby's species, and he has not met with a single yellow one on any species of that family. On the contrary, all the specimens he has found on the *Nomadæ* and *Volucellæ* have been yellow, like the larvæ of *Meloë*. This was the colour of the specimens described by Reaumur, Fabricius, Olivier, &c. Baron Walckenaer

of the Meloës I have examined, although I am equally satisfied that they are the larvæ of some genus of the same family*. The larvæ I have reared from the eggs of *Meloë violaceus*, *M. proscarabæus* and *M. cicatricosus* have always so exactly resembled each other in their yellow colour and in form, that I have been unable to distinguish them, excepting by a slight difference in size. The larvæ of *M. cicatricosus* are a little larger than those of the other species. I may also state, that these larvæ always retain their yellow colour, and only become a little darker after they have been several days from the egg. These facts seem to identify the true larvæ of *Meloë* with the yellow hexapods taken on dipterous and hymenopterous insects. DeGeer† found them on a specimen of *Musca intricaria*, L., and on comparing those which he had reared from the egg with those taken on the fly, he could perceive no difference between them. Reaumur also captured one on the body of an Apiform *Musca*, which he has figured and described‡, and which agrees precisely in every respect with the young *Meloë*; and Mr. Kirby§ remarks that these hexapods are not uncommon upon the bodies of the *Andrenidæ*, that he has found fourteen or fifteen upon the same individual, and that he has also met with them on the genuine *Apidæ*. I have fully satisfied myself of the correctness of this statement by experiment with specimens reared in 1836. I placed a female *Eucera longicornis* in a small phial with a brood of these larvæ, and it was instantly attacked by them. This identical specimen, preserved in spirit, with the larvæ attached to it, I have now the pleasure of exhibiting to the Society. It is astonishing to observe with what celerity they attach themselves to their victim the instant any part of its body is within reach; and with what tenacity they adhere to it, seizing it by the leg, the wing, or the

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also (Mémoires pour serv. à l'Hist. nat. des Abeilles solitaires qui composent le genre Halicte, Paris, 1817, pp. 85–87) describes a specimen of a yellow colour found on *Halictus Elephas*; and he remarks, that it differs from that of Mr. Kirby in having the exterior of the caudal setæ on each side longer than the interior, in which respect his species seems to differ also from the larvæ of *M. violaceus* and *M. proscarabæus*.

* The larva of *Cantharis vesicatoria* is described by M. Zier as very like that of *Meloë*. He says that it is of a yellow colour when it leaves the egg, but soon afterwards changes to deep black. Perhaps the larvæ described by Mr. Kirby, and that found by myself on *Osmia*, may be more nearly allied to this insect.

† *Loc. cit.* ‡ Mémoires, tome iv. Mém. ii. p. 490. tab. 31. fig. 17. § *Loc. cit.* p. 168.

under surface of the thorax, or by the hairs of its body; mounting in crowds upon its thorax, and adhering thickly around the insertion of its legs, between the head and corselet, the thorax and abdomen, and on its under surface; evidently exciting the greatest possible uneasiness to the fated insect, as indicated by its constant but fruitless endeavours to detach them from its body. Indeed, as DeGeer naively remarks*, "On peut bien s'imaginer, qu'une mouche, chargée de tant d'ennemis, ne devoit pas être à son aise; aussi fit-elle tout son possible pour s'en débarrasser, frottant sans cesse les pattes tantôt contre le corps et tantôt les unes contre les autres; mais tous ses efforts furent inutiles, aucune de ces larves ne voulant lacher prise." But when the death of the victim occurred, these larvæ, like all other parasites, immediately left it.

The parasitic habit of *Meloë*, in its earliest stage, being thus established, we have now to ascertain what is its immediate object. Whether, is it to procure food at once from the body of its victim; or is it that the larva may be conveyed to a proper locality, in which it is to find means of support and development? I am greatly inclined to this latter view, which the details I have presently to communicate respecting the full-grown larva and the pupa will not only show is most consistent with the known habits of the imago, but will also tend to reconcile the facts respecting the parasitism of the larva with the imperfect accounts that have been given by Frisch and Geoffroy.

We have seen that the eggs of *Meloë* are deposited at the roots of grass in situations exposed to the sun; and that the larvæ are often found on the bodies of those hymenopterous insects which burrow into the earth, or perforate hard banks of clay or sand to form nidi for their young; and that they are also found on dipterous insects which frequent the nests of those very Hymenoptera as parasites. In this way the young *Meloë* may be carried, either by the parent bee, or by its parasitic enemy, into the nest where it is to be nourished, either with food prepared for, or on the bee-larva itself. This seems proved by the fact, that I have discovered the full-grown larva in the nest of *Anthophora retusa*. All the Hymenoptera on which the Meloës have been found burrow in sandy or clayey soils; and I believe all the Diptera on which they have been taken are parasitic in the nests of the Hymenoptera. Of the former, there are the *Andrenidæ*, the *Euceræ*, the *Osmiæ*, *Anthophoræ* and

* Mém. tome v. p. 11.

Bombi; and among the latter the bee-formed *Volucellæ*. Now it is easy to conceive that the young Meloës, attracted as they always are by light, ascend the stems, and repose in the calyces of flowers, and attach themselves to the bee when it alights to collect honey or pollen, or to its dipterous parasite. I am strongly inclined to believe that this is in reality the way in which they get access to the bees, as I remember to have once observed, on a hot sunny day, a vast number of minute yellow hexapods, very similar to those of *Meloë*, lying quietly between the petals of the flower of the dandelion, but which were instantly in motion as soon as the flower was touched.

I have stated that the young Meloës are quickly aroused to activity by exposure to light. When first developed from the egg in the earth, they remain for a time collected together in a heap, and, as already shown, if entirely excluded from light, they will remain undisturbed for several days. But they are aroused to immediate activity the instant they have escaped from the egg, by the presence of light, and begin to separate and disperse in a direction towards it. Light indeed seems to be their great stimulus to active existence, as there is reason to believe it is the great awakener of the first instinctive act of volition in the newly-born young of all the *Articulata*, and probably also of the whole animal creation. A marked instance of its direct influence in arousing the voluntary powers of a young *Iulus*, that had just escaped from its fœtal coverings, was formerly pointed out by myself in a paper in the 'Transactions of the Royal Society*,' and similar effects are produced by it in the young *Meloë*. The marked influence of light on these diminutive beings has constantly excited my admiration whenever I have succeeded in obtaining them from the egg; and on every occasion it has produced similar effects. I have usually confined my young Meloës in a corked phial placed in the window of my apartment. In the morning and through the early part of the day they are in a state of constant activity, distributed over the whole interior of the upper part of the phial; but in the afternoon, in proportion as the light is diminished, they become more and more inactive, and at length perfectly quiet, collected together in a heap, clustering like bees at that side of the upper part of the phial that is most exposed to light. In order fully to satisfy myself that it is indeed the stimulus of light which

* Phil. Trans. part ii. 1841, p. 118.

seems so completely to influence their movements, I have frequently inverted the phial that contained them, so that they were then at the bottom. Instantly the whole were in motion, travelling in haste perpendicularly up the sides of the phial to that part which was then the top, and most exposed to light. I have then placed the phial in a horizontal position, with that end of it in which the larvæ were collected furthest removed from the light, and again the whole were travelling rapidly towards it at the opposite end of the phial. In this way they can at any time be aroused to a state of great activity, especially if the light to which they are exposed is intense, whether it be artificial or bright sunlight. That it is light which acts thus powerfully upon them seems to be proved by the circumstance that, if the stopper be removed from the mouth of the phial when they are collected around it, and the phial be then placed in a horizontal position with its closed end to the light, the larvæ do not attempt to escape through the opened mouth, although nearest to it, but instantly travel in the opposite direction towards the light. Thus the unerring influence of a great physical cause, that arouses the instinct of the newly-developed being, seems to be clearly indicated in the effects of light upon these Meloës. These effects I may perhaps be allowed to designate, —the polarization of Instinct.

The influence which light produces on the instinct of the young Meloës accords with their presumed ascent on the bright-coloured flowers of the dandelion and buttercup, preparatory to their attaching themselves to the Hymenoptera that visit these flowers to collect pollen. Every circumstance we are acquainted with respecting the Mcloës seems to confirm us in this view of their habits. Their extremely diminutive form, their lightness and activity of body, the celerity with which they attach themselves, and the pertinacity with which they adhere to the objects within their reach, and their extreme susceptibility of external influences,—all coincide to prove their parasitic nature. They seem indeed in every respect most fitted and designed, by the Great Author of their being, to attach themselves securely to their victims, and be wafted about from flower to flower on the bodies of other insects, in the full joyousness of open daylight, while being conveyed to the proper locality for their development. This, doubtless, is the instinct that urges them to attach themselves to the *Hymenoptera,* to be carried to

the nests that are stored with food; and a similar impulse leads them to cling to those *Diptera* which frequent the nests of the bees as parasites.

But although every circumstance has tended to prove the correctness of this view, which seems confirmed by the fact, that I have repeatedly obtained the adult larva, and the nymph or pupa of one species, *Meloë cicatricosus*, from among the nests of *Anthophora retusa*, I have endeavoured to ascertain whether the young Meloë is a parasite on the bee-maggot itself, or whether it is nourished with the pollen stored up as food for the young bee? With this object in view, in June 1842 I took with me to Richborough, where I had obtained the full-grown larva and nymph, an abundance of larvæ recently developed from the eggs of *Meloë violaceus* and *Meloë proscarabæus*. Previously to making any trial with these specimens in the nests of *Anthophora*, I had placed a few in the cells of a piece of old honeycomb, and found that, contrary to their usual habit of wandering, they remained perfectly quiet at the bottom of the cells. From this circumstance I hoped to succeed with them in the cells of *Anthophora*.

The specimens taken with me to Richborough came from the egg on the 14th of June. On the 23rd of the same month, at midday, when the temperature of the atmosphere was 69° Fahr., I placed some of these young Meloës in nests of *Anthophora retusa*, which contained each a bee-maggot, and a large quantity of pollen paste, its proper food. The Meloës at that time had been nine days from the egg, but were perfectly healthy and active, although they had not taken any nourishment. At first I believed that the experiment had succeeded, as one of the specimens began immediately to attempt to pierce the skin of the bee-larva with its mandibles, and, as I then supposed, was feeding on its juices. But closer examination soon occasioned me to doubt that the larvæ of *Anthophora* are the proper food of the species with which I was making the experiment. In order further to assure myself of the truth, I put several larvæ of *Meloë* into the cells of *Anthophora*, and left them for further examination. On the following day I again visited the spot, but could not discover a single larva of *Meloë* in the nests in which I had placed them. The larvæ of *Anthophora* were still there, with their cells stored with food, but the Meloës were gone.

To ascertain more decidedly whether the young *Meloë* is parasitic on the body of the bee-larva, I selected three specimens of larvæ of *Anthophora* of

different sizes and ages, and having placed each in a separate glass tube, included with them in each tube five or six of the larvæ of *Meloë*. At first the Meloës collected on the body of the bee-larva, and appeared as if inclined to feed upon it; but having left the tubes undisturbed for the night, I found at the expiration of eighteen hours that the Meloës were removed from the larva, and collected together as usual at the upper part of the tube. At the expiration of forty-two hours they remained in the same state, so that the only conclusion I was enabled to arrive at was, that the larvæ of *Meloë violaceus* and *Meloë proscarabæus* are not parasitic on the half- or full-grown larva of *Anthophora retusa*. Yet from the circumstance of their always attacking the larvæ in these experiments, there seems reason to suspect that they may prey on the very young of some species of bee, soon after it has left the egg, although not in its advanced growth. It was unfortunate, that at the time of making these observations I had not any young larvæ of *Meloë cicatricosus*, the species which I have constantly found in the full-grown larva state, as well as in that of the nymph, and of the recently-developed perfect insect, in the same bank with, and amongst the nests of *Anthophora*, and I have not since had any opportunity of pursuing my researches with the young of that species. I ought here to state, that although I have for several years past obtained *Meloë cicatricosus* in all its stages from localities crowded with the nests of *Anthophora*, I have never obtained either *M. violaceus* or *M. proscarabæus* from the same spot, although the whole of these species are very common in their perfect state in the meadows immediately adjoining the bank in which I have found *M. cicatricosus* and the *Anthophoræ*. The conclusion therefore which seems to be indicated is, that although the whole of the species of *Meloë* reside as parasites in their larva state in the nests of *Hymenoptera*, only *M. cicatricosus* is parasitic on *Anthophora retusa*. The great length of time which the larvæ of all the species can live without taking food after they have left the egg, is indicative of a precarious mode of existence. Most of the specimens I have reared have lived from fifteen to twenty days after coming from the egg, and during that period have not much increased in size, but have died, apparently from want of proper nourishment.

Although I have not traced the young larva of *Meloë cicatricosus* directly into the nest of *Anthophora*, I will now endeavour to prove that that is the locality in which it resides as a parasite, and where it undergoes its develop-

ment; and also, that its rate of growth is as rapid as its change of form is extraordinary. I have already stated that the perfect insect is most abundant about the middle of April, and deposits its eggs towards the latter end of that month, or in the beginning of May; that the eggs are hatched in from three to five weeks, according to the temperature of the season; and that the larvæ come forth at the end of May, or in the beginning of June. This is the period when the *Anthophoræ* are most busily employed in constructing and storing their nests, in places that are constantly exposed to the sun, and when many of their eggs are already hatched. I have little doubt that it is at this period that the *Meloë* attaches itself to the parent bee when she alights on the flowers for pollen, and is conveyed by her into her nest while storing it with food, as suggested by Latreille. The growth of the bee-maggot itself at this period of the year is exceedingly rapid; and this rapidity is owing as much to the very high temperature of its cell—(which I have elsewhere* shown sometimes exceeds 80° Fahr.), and also to the powerful influence of the light of the morning and midday sun, to which the banks where the nests are constructed are exposed,—as to its nutritious food. Like circumstances appear to hasten the growth of the larvæ of *Meloë*. The full-grown bee-larvæ are found in abundance in the month of July, and many of them have already changed to nymphs by the beginning of August. It is at this period that I have obtained many full-grown larvæ of *Meloë* in cells surrounded by those of *Anthophora*. From these facts it is fair to conclude that those Meloës which are developed from the first laying of eggs arrive at their full growth within a very few weeks, as I have invariably found the full-grown larvæ by the middle of August, at which time also, like the *Anthophoræ*, many have already changed to the state of nymphs. The shortness of the period which seems thus to be occupied in the larva state, and the consequent rapidity of the almost total change of form which it undergoes, may in part account for the circumstance that the full-grown larva has hitherto so entirely escaped the observations of naturalists.

After many fruitless attempts, through twelve years, to find specimens of the larva of *Meloë* in a stage intermediate between the very young and the adult form, I had almost despaired of success, until, in the present autumn, in October last, on visiting the same bank at Richborough from which I have

* Phil. Trans. part 2, 1837, tab. 3. p. 279.

repeatedly obtained the adult larva, I discovered three specimens of the larva of a coleopterous insect in a cell that contained also the living nymph of *Anthophora retusa*. These specimens differ so much in their general appearance from the adult form of the larva of *Meloë*, that I have doubted whether they are not the young of some other insect. On close inspection however they present certain marked peculiarities which seem to identify them with the other stages of *Meloë*. These specimens are still living, and I have now the pleasure of exhibiting one of them to the Society. They are short, fat, but rather active larvæ, of a yellowish-white colour, with the head and organs of nutrition corneous, and of a brownish hue. They resemble the earlier state of *Meloë* in the general contour of the head, and in the peculiar form of the antennæ, the middle joint of which is enlarged and club-shaped, while the two terminal joints are very slender, and end in an acute point. The parts of the mouth also present great similitudes. The mandibles are acute, but are much shortened, and more resemble those of a vegetable-feeding insect. The maxillæ and palpi are very like those of the young *Meloë*, while the labium presents the same deep emargination as in the earliest stage of that insect. The caudal appendages also exist, but are shortened, and are evidently about to disappear. On the other hand, the whole general form of the larva is different, and more resembles that which the *Meloë* assumes when full-grown. The thorax is rounded in front and dilated at its sides, and there is no division of the body into trunk and abdomen, the whole of the segments having assumed one general appearance, those of the posterior part of the body being most enlarged. The legs are considerably shortened, and have not the tarsal spines, the two lateral portions of the claw.

As I have not yet reared the adult larva of *Meloë* from this state, I will not describe it positively as the young of that insect, although I suspect that such is the fact. I am quite satisfied that *these* larvæ, although found in a cell with the nymph of *Anthophora*, are not parasitic on the insect itself. In the short time I have yet had to notice their habits, I have convinced myself that they do not attack the bee-nymph, but only conceal themselves beneath it. They seem now to feed on the debris that the larva had passed from its body before changing to a nymph. I have no doubt that their proper food is the pollen-paste stored up for the bee-larva. If these specimens should ultimately prove to be the young of *Meloë*, this will explain what has hitherto

been regarded as a singular anomaly in the supposed parasitic habits of the insect, and show that, although it resides as a parasite in the nest of another insect, its food is constantly of a vegetable nature*. *Meloë cicatricosus* is most certainly parasitic in the nest of *Anthophora retusa*; as the Rev. Lansdown Guilding† has already shown that the larva of another genus, *Horia maculata*, is on the carpenter-bee of the West Indies, *Xylocopa Teredo*.

I have now only to show the remaining states of *Meloë*. Geoffroy‡, as I have already shown, has stated, that the larva of *Meloë* resembles the perfect insect; that it is of the same colour, is fat, sluggish, has the head scaly, and the rest of the body soft, and that it is buried in the earth, where it undergoes its metamorphoses. This description of the larva so little agrees with the specimens I have obtained, and know to be the larvæ of *Meloë cicatricosus*, that I am satisfied Geoffroy must have confounded this with some other species. Frisch§ was better informed. He represents the larva as undergoing "several changes of skin, in the last of which it acquires its wing-shaped cases." He also states, "that it remains during the winter in claycy earth, where no humidity can reach it, and that it comes forth in the month of May." This account of the latter changes of *Meloë* is correct. The larva of *Meloë cicatricosus* certainly undergoes several changes of skin, in the last of which, previously to entering the nymph state, it is a thick, fat, heavy, inanimate, and almost completely apodal maggot, of a light orange colour, pent up in its cell in the dry bank of clay or sand amongst the nests of *Anthophora*. It has entirely thrown off its caudal appendages, its setæform antennæ, and its elongated legs. In place of the latter it retains only six short tubercles on the under surface of the anterior segments. I have found it in this state in considerable numbers in the clay-bank at Richborough, in the months of August and September, in the years 1832, 1834, 1842, and during the present autumn. It is always concealed in a closed cell, in those parts of the bank in which the bees' nests are most numerous and crowded together. Although its cell is nearly of the same size as that of *Anthophora*, and seems to have been originally formed by that insect, it is not then a smooth oval

* These larvæ proved afterwards to be those of *Cryptophagus cellaris*, Payk.—See next memoir.

† Trans. Linn. Soc. vol. xiv. p. 316. ‡ Hist. Ins. tome i. p. 377.

§ Insect. fasc. 8. tab. 16; 1728? and as quoted in Swainson and Shuckard's 'History and Natural Arrangement of Insects,' Cabinet Cyclopæd. 1840, p. 328.

cavity, like the cell of the bee; but it is somewhat more elongated, and is a little irregular in its interior, as if altered by the larva before its previous change of skin. The larva then measures three-quarters of an inch in length. It is composed, as in each of its preceding stages, of fourteen segments, and has ten pairs of spiracles. It is of a semilunar form, with the sides of its body thinned and dilated. It has a small head, with short tuberculiform antennæ, palpi and legs. The tegument thrown off at its previous change of skin, —up to which time it seems to continue in an active state,—always remains partially adhering to the inferior and posterior surface of its body. On removing this tegument and relaxing it in water, and then examining it with the microscope, I have obtained good evidence that the larva in all its preceding states is an active creature, furnished, as in the state in which I have found the larva just described, in the cell of the bee-nymph, with strong, toothed, and slightly obtuse mandibles. Up to the period of change to the almost apodal larva it retains its three pairs of short scaly feet, each formed of a coxa, femur, tibia, and tarsus, terminated by a single, short, but strong claw, the lateral divisions, or tarsal spines, having been entirely lost. These circumstances lead us to further inquiry respecting the early habits of this anomalous creature. Does it remain constantly in the same nest of *Anthophora*? or is it erratic, and accustomed to penetrate into different nests for food, and at last remain in one to undergo its transformations? The hard structure of its mandibles and claws seems to indicate some such habit.

Such is the larva of *Meloë*. The length of time it remains in its helpless and apodal state is not many days. It then changes to a nymph, without entirely throwing off the larva-skin, which is simply fissured along the dorsal surface of the thoracic segments, and detached from the body. It remains inclosed in this skin, like a corpse in its shroud, up to the time when it assumes the imago state, by throwing off a very thin pellicle. This takes place within ten days or a fortnight after the larva has become a nymph; but if the season is unfavourable, the period of this completion of its changes is retarded. It remains in its cell through the autumn and succeeding winter as a perfect insect, in a state of hybernation, until it is aroused into activity by the gradually increasing influence of the season, and leaves its nidus early in the following spring.